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LECTURES

ON

AGRICULTURE,

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From H. Garrett
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DELIVERED BEFORE THE

Downingtown Society

FOR THE

ACQUISITION AND PROMOTION

OF

NATURAL KNOWLEDGE.

BY

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TORIC
CIET
OF
DELAWA

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13

CONTENTS.

Page.
Lecture 1. Introductory,........................ 1
" 2. On soils, their component parts, and the properties of those parts, 9
" 3. History of Agriculture,........... 18
" 4. On the nature of soils,............ 25
" 5. On the Soil, and methods of testing its State,...................... 30
" 6. On Vegetables,....... 34
" 7. On Vegetable Substances,........ 37
" 8. On Vegetable Substances,........ 44
" 9. On Manures,........................ 51
" 10. A short view of some of the errors of Husbandry,............... 59
" 11. On the General powers of matter which influence vegetation,..... 63
" 12. On Agricultural Chemistry,...... 69
" 13. On the Phenomena of Fluidity, 78

LECTURE I.

INTRODUCTORY.

Agriculture, though long the subject of attention, is still but imperfectly understood. It is, therefore, desirable that it might obtain a deliberate investigation of all its principles, and that these should be so clearly developed as to be easily comprehended. From the light of modern science, combined with those experiments upon the soil which are annually made, it may be expected that a new and valuable era is taking place in agricultural concerns, and that ignorance and prejudice will be erased from the minds of those who are cultivators of the earth. To afford some assistance in removing such prejudice, and thereby increase the knowledge of a rational system of Husbandry, would be gratifying to your lecturer on this subject, and he is satisfied would comport with your views in making the appointment. Long established customs it is difficult to contend with, and these, among farmers, have their influence, as with other classes of men. It is not uncommon to hear them speaking of the advantage to be gained by observing the right time of the moon. This luminary has been so much consulted that you might suppose there was more attention given to it than to the soil. There are, at present, Almanacs in use in which the right time of the moon for spreading manure, setting fences, and various other purposes are particularly pointed out. Besides the prejudices of this kind, we have to regret the prevalence of ignorance in treating the diseases of domestic animals. Almost every neighborhood has its doctors, whose remedies, operating by no common principles in nature, are relied upon with a confidence equal to the implicit faith which, in darker ages of the world, was held by the deluded multitude in a corrupt clergy. Those quack professors have their supposed lucky seasons; they are, of course, to be visited at particular times of the moon, and it is then we may see many of our farmers with their diseased animals, brought together to be cured of their several maladies, by remedies that no one professes to understand. The cultivation of the soil is necessarily connected with the care of domestic animals, these are liable to various diseases, and it might be expected that, in a course of lectures devoted to the science of agriculture, notice should be taken of this subject, but it will be advisable to leave it in other hands. By embracing more than can be correctly examined and understood, our principa object in appointing a lecturer on agricultur would be liable to be defeated. It is however desirable that the study of the diseases of domesti animals, and the remedies proper to remove them should engage the attention of able and generous minds, and that so valuable a blessing to man as this part of creation, might be taken out of the hands of ignorant professors.

In attempting to explain the principles of agriculture, it is believed best to treat of them distinctly, and a hope is entertained that the laws by which they are regulated will be developed. By this means a system may be discovered which shall combine simplicity with usefulness, and thus contribute to the improvement of cultivation. Such a system, embracing philosophical illustrations of the principles of agriculture, might prove a happy excitement to many of the rising generation to pursue an agricultural life, in preference to other occupations of a more uncertain and dangerous kind. It is from a correct cultivation of the soil that our substance and wealth must be expected. In the same proportion, therefore, as the light of science shall succeed in dissipating the darkness of ignorance, will the system of cultivation be perfected. Hence we may rationally conclude that the farming interest will be improved, and the fertility of soil correspond with an enlightened and correct judgment in the cultivator. Let the blessing of an improved mind become general, and the farmer be expanded in the knowledge of sound philosophy; he will then be prepared to understand the laws which operate upon this visible world, and, by applying his means in agreement therewith, he will cause the wilderness to be fruitful and the desert to blossom as the rose. Had the intrepid and vigorous talents possessed by the heroes of antiquity been devoted to our subject, "the former fertility of Italy, of Greece, and of Egypt, might have stood as monuments of human ingenuity to succeeding time," and we should, by this period, have been blessed with chemical explanations of different soils. But history has led us back to those miserable ages of mankind and repaid our anxious enquiries with little more than a melancholy picture of human depravity—its volumes record the names of men, famous for desolating every improvement and wasting every hope of tranquility, and these, too, have been the pride of deluded empires and kingdoms; at their feet have bowed the philosophers of antiquity. With their love of power and splendor, they have laid prostrate every improvement which they found in the country of an alleged enemy. It remains for those of enlightened ages to cultivate the arts and sciences, to improve their more favorable opportunities, and lay the foundation for rational life. In the same proportion as the human mind is improved, in that proportion a liberal spirit will be excited, and it is impossible to calculate what shall be extent of improvement at which this world may arrive under a series of auspicious circumstances. Already we find many things understood, which, we believe, never entered the mind of an Alexander, a Hannibal, or a Cæsar. Mysterious, therefore, as are many of the subjects of science, those which belong to that branch included in the phenomena of vegetable matter, and which command our deliberate attention, may, nevertheless, become simple and easy by application.

Our faculties are limited; by what boundary is yet unknown. The same inexhaustible fountain of intelligence that gave us being, designed our improvement; and, if we judge from anology, we shall conclude that the more we are improved the better we are prepared for improvement. Having therefore a wide field of manure open to us, the product of that same intelligent Being who gave us existence, we cannot believe it was furnished in vain, and consequently infer that the careful application of our talents, to the acquirement of useful knowledge, is both our interest and our happiness. Had this laudable ground been taken by the generations which were before us, we should have found a world acquainted with many more of its material principles; and the science of agriculture, instead of being obscured by ignorance, might have stood pre-eminent among the works of philosophers, and explained in the mind of every intelligent farmer. You will no doubt excuse the ardor of my feelings upon this important branch of science. Wherever I turn my eyes, new excitements are experienced. If I look back upon mankind, there I find all has been confusion and error

If I come within our time and country, the call is imperious to awaken fellow citizens out of deception, that they might no longer torture creation by abuse and folly. Many thousands of acres of land, which, at this time, should serve to support a numerous and happy population, are literally exhausted and deserted. It would seem, from this fact, as tho' man, instead of contributing to the improvement of the gifts of Heaven, was the curse of all nature, and that poverty and misery were destined to follow his footsteps.

It is proper to observe, in this introductory essay, that highly laudable exertions have been made by a number of very respectable citizens, associated under the title of the Philadelphia Society for promoting Agriculture.—This society have published four octavo volumes, containing interesting and useful memoirs. It would be a means of enlarging our knowledge in agriculture, if we were furnished with chemical explanations of different soils; they will be sought for, with a view to introduce such of them into subsequent lectures as may be thought useful. The properties of plants, more particularly those which belong to the agricultural interest, will also be attempted to be explained, and their simple elements stated. On those last mentioned particulars, it is hoped assistance will be gained from the labors of the society, when it shall become fully organized and in regular operation. We knew that much remains to be acquired, and we may reasonably look for an increase of knowledge of the principles of nature, if we steadily pursue the design of our association. At present the evils attached to a mistaken course in agriculture are numerous. Our country is entangled with impediments which retard its progress. Among these a reliance upon the labour of slaves must necessarily be included. Every part of farming requires a combination of practical knowledge with enlightened judgment, and it would be as rational to expect ignorance to furnish perfection, as to suppose that a slave would be the means of improving the soil. We have only to instance the neglected state of improvement in a country of slave holders to support this view. The soil they occupy, has declined in their hands, and many of them are removing to lands which are new and fertile, because they can no longer subsist upon those which they have heretofore occupied. If the same causes produce the same effects, nothing can be expected by the employment of slaves on a new soil, better than has been already produced. This subject is mentioned, because it may be estimated as an injury to agriculture, and because it demands the careful attention of our government to remove it. I have not designed to animadvert largely upon slavery. The present state of this subject we may sincerely regret, and our sympathies cannot but be awakened for those whose ancestors have brought upon them this difficulty. It is at present a national evil and calls for a national remedy. The next subject which I intend to embrace will be the soil. I shall consider this the commencing point, and aim at giving all the explanations upon it that can be collected in the time allotted.

LECTURE II.

ON SOILS, THEIR COMPONENT PARTS, AND THE PROPERTIES OF THOSE PARTS.

In our introductory lecture, the society were informed that our next should treat of the soil in its natural state. It is now proper to take up this subject, and to furnish such information upon it, as could be obtained. In the first place, it may be stated that the extensive variety of soils which are found in all countries, are a phenomena in nature not understood. It is possible to account for the richness and fertility of some situations from local causes. The overflowing of the Nile in Egypt, must have enriched those parts by the vegetable and other matter deposited as a sediment.—Simiar causes may have operated on a smaller scale in many other situations, and where this has been the case, the circumstances which have contributed to produce those instances of superior fertility are understood. But these do not give a solution of the general phenomenon. Our earth is diversified with hills and dales, with lofty mountains and deep vallies. We know these facts, and we know too that individuals have attempted to explain the causes of their production; but as such explanations have been the fruit of imagination, and do not ppear to be built upon any principles which are nderstood, it is proper to shun them as dangerous, nd calculated to lead into error. The laws of evidence in the material world have been justly confined to two principles, and these are either the observations which we make ourselves, and therefore know to be true, or they are such testimonies of the facts observed by others as are reasonably authenticated. We are incapable of making satisfactory observations of the causes which produced the difference of soils, and we can have no testimony from others on this subject, founded upon their own observation.—The wide field of diversity in the soil, must therefore be taken as a fact. and as its circumstances naturally vary from each other, we may conclude that the great Author o nature, in this instance, has laid the foundation fo man's industry, and that hence he is called upon t examine the difference between the barren and productive soils, to make himself acquainted with th constituent parts, that he may be prepared to improve the defective, and add to the beauty an value of his earthly inheritance. Thus he may understand the laws that govern the soil, the vegetable tribes, and while he is acquiring knowledg and enlarging his judgment, he may be entertai ed with the fruits of those acquisitions and see th prosperity of the labor of his hands. To promo those important ends we shall now examine th soil; we shall take into view those facts in relati to it, which have been laid open by chemic analysis, and which are as follows:

Though there seems to be an almost infinite v riety of earthy substances scattered on the surfa of this globe, yet when we examine them with chemical eye, we find that all the earth and ston which we tread under our feet, and which compo the largest rocks, as well as the numerous diffe ent specimens which adorn the cabinets of the c rious, are composed of very simple or elementa earths; in number no more than six, the Silex, t

Alumine, the Glucine, the Zircon, the Yttria, and the Magnesia.

General physical properties of Earth.

All earths are dry, incombustible bodies. They are insoluble in water and alcohol, or nearly so. They have little or no taste. Their specific gravity does not exceed 4.8. When perfectly pure, they assume the form of a white powder, harsh to the touch. They are capable of combining with acids, when they form neutral salts. They are likewise disposed to unite with the alkalies, with sulphur and phosphorus, with metallic oxyds, and with each other, either by fusion or solution in water.

Every one of these characters is not perhaps rigorously applicable to each of these bodies, but they all possess a sufficient number of them to render it useful to arrange them under one class.

Stones differ from earths, principally in cohesion and hardness, and therefore are included under the same general name.

Silex.—Natural history of Silex.

Silex, or Siliceous earth, is the principal constituent part of a very great number of the compound earths and stones, forming the immense mass of the solid nucleus of the globe. It is the basis of almost all the scintillating stones. The sand of rivers and of the sea shore, chiefly consist of it. It is deposited in vegetable substances, forming petrified wood, &c. It is likewise precipitated from certain springs in a calcareous secretion of a stalactical form. It has been discovered in several waters in a state of solution, and is found in many plants, particularly in grasses and equisetums. Professor Davy has proved that it forms a part of the epidermis of those vegetables. It is never met with absolutely pure in nature.

Properties of Silex.

Silex, when perfectly pure, exists in the form of a white powder. It is insipid and inodorous. It is rough to the touch, cuts glass, and scratches or wears away metals. Its specific gravity is about 2.66. It is unalterable by the simple combustible bodies. When mixed with water it does not form a cohesive mass. Its moleculæ, when diffused in water, are precipitated with facility. It is not acted on by any acid, except the flowric. When in a state of extreme division it is soluble in alkalies, fused with them it forms glass. It melts with the phosphoric and boracic acids. It is unchangeable in the air, and unalterable by oxygen and the rest of the gaseous fluids. It has been considered as insoluble in water, but it appears when in a state of extreme division, to be soluble in a minute quantity.

Natural History of Alumine.

This earth derives its name from Alum, of which it forms the base. It constitutes the lower strata of mountains and plains. It arrests the waters, and causes them to rise in springs to the surface of the earth. It enters into the natural composition of the schistur sistus, and all those stones and earth called argillaceous potter's clay.

Properties of Alumine.

Alumine is white and soft to the touch. It is insipid, adheres to the tongue, and occasions a sense of dryness in the mouth. When moistened with a small quantity of water, it forms a tenacious, ductile, kneadable paste. When heated to redness, it shrinks considerably in bulk, and at last it becomes so hard as to strike fire with flint. After being ignited, it is no longer capable of being kneaded with water into a ductile mass. It recovers, however, this property by solution in acid, and subsequent precipitation. Alkalies dissolve it in the humid way, and form compounds decomposible by acids. It dissolves slowly in all acids. It possesses a powerful attraction for lime. The most intense heat of our furnaces is not able to melt it, but it becomes fusible when lime is added. Lavoisier has proved that it is capable of entering a kind of fusion-like paste, by the action of oxygen gas, it then cuts glass and resists the file. It absorbs water and carbonic acid from the atmosphere. By its mixture with water and silex, it acquires great solidity. It does not unite with any combustible substance, but becomes fused into coloured frits with metallic oxyds. Its specific gravity is 2. It is employed in a multitude of arts.

Natural History of Glucine.

For the discovery of this earth, we are indebted to Vauquelin, who found it in 1794, in the aguemarine, or beryl, a transparent stone of a green color, and in the Emerald of Peru. It exists combined with silex, argil, lime and oxyde of iron in the one, and with the same earths with the oxyde of chrone in the other. It has lately been discovered in the Gadolonite. Its name is taken from the Greek word Glukus, which signifies sweet or saccharine, because it gives that taste to the salts it forms.

Properties of Glucine.

Glucine is white, light, and soft to the touch. It is insipid, and adheres to the tongue, and is infusible by itself in the fire. Its specific gravity is 2.967. It is soluble in alkalies, and their carbonates, and in all the acids except the carbonic and phosphoric, and forms with them saccharine and slightly astringent salts. It is exceedingly soluble in sulphuric acid used to excess. It is fusible with borax, and forms with it a transparent glass. It absorbs one fourth of its weight of carbonic acid. It decomposes sulphate of alumine. It is not precipitated by the hydrosulphurets, nor by the Prussiate of potash; but by all the succinates. Its affinity for the acids is intermediate, between magnesia and alumine.

Natural History of Zircon.

This earth was discovered in the year 1793, by Klaproth of Berlin, in the Zircon or Jargon, a gem first brought from the island of Ceylon, but also found in France, Spain, and other parts of Europe. Its colour is either gray, greenish, yellowish, reddish, brown or purple. It has little lustre and is nearly opaque.—It is likewise found in another gem called the hyacinth; this stone is of a yellowish red colour mixed with brown—it possesses lustre and transparency.

Properties of Zircon.

Zircon earth has a white colour, is exceedingly heavy and rough or harsh to the touch like silex. It has neither taste nor odour and is insoluble in water, but forms with it a kind of jelly.—It melts with borax into a transparent colourless glass—it suffers in a charcoal crucible a pasty fusion, by intense heat, and contracts in its dimensions, acquiring a gray colour and scintillating hardness. In this state it is very hard and insoluble in acids. Its specific gravity is 4.3—Neither air nor combustible bodies act upon it. It is soluble in water, but retains while drying in the air, a large quantity of it, which gives it the semi-transparency and appearance of a yellow jelly or gum arabic. It exhibits the same vitrious fracture—It unites with all the acids, and forms salts differing from those of the other bases by being decomposible by alumine, glucine, the alkalies, and by mere heat. It fuses with alumine and silex: it is insoluble even by boiling in a solution of alkalies, neither can it be fused with them by means of heat, but it is soluble in alkaline carbonates: by these properties this earth may be distinguished from every other.

Natural History of Yttria.

The discovery of this new earth in a fossil termed by Gadolin Yttria, from the place where it was found, has lately been confirmed by Vauquelin and Klaproth.

Properties of Yttria.

Yttria is the heaviest of the earths.—Its specific gravity is 4.842. It resembles glucine in several of its properties. It is smooth and insipid —It is infusible alone, but vitrifies with common borax. It combines with the acids and is precipitated from those solutions by ammonia and prussiate of potash. It is also precipitated by tarmin. The precipitate is not soluble in acetous acid; as some of its salts are coloured and its weight nearly approaches to that of metals, it is considered as the link which connects the metals with the earths. It differs from glucine in not being soluble in fixed alkalies, nor being precipitated by the succinates. Its attraction for the acids is also in general stronger than that of glucine, and its saline compounds have not the same saccharine taste. Its other properties have not yet been examined.

Natural History of Magnesia.

This earth is not found pure in nature, but is obtained by art from some of its combinations. It gives a peculiar character to the substances of which it forms a part. The stones which contain magnesia in considerable quantity, have generally a smooth and unctuous feel, a greenish cast, a fibrous or striated texture and silky. It is likewise found neutralized with various acids. It has been discovered by Vauquelin in several seaplants.

Properties of Magnesia.

Magnesia does not form with water an adhesive ductile mass: it is in the form of a very white spongy powder, soft to the touch and perfectly tasteless. It is very slightly soluble in water; it absorbs carbonic acid, gradually from the atmosphere. It changes very delicate blue vegetable colours to green. Its attraction to the acids, is weaker than those of the alkalies. Its salts are partially decomposed by ammonia; one part of the magnesia being precipitated, and the other forming a triple compound. Its specific gravity is about 2.3. It is infusible even by the most intense heat, but when mixed with some of the other earths, it becomes fusible. It combines with sulphur—It does not unite to phosphorous or carbon—it is not dissolved by alkalies in the humid way. When heated strongly, it becomes phospherescent. With the dense acids it becomes ignited. With all the acids, it forms salts of a bitter taste, mostly very soluble.

LECTURE III.

History of Agriculture.

It may readily be conceived that the cultivation of the earth commenced at an early period of mankind. There is, however, some difficulty in determining the precise point of time. To suppose that any thing like sowing or planting seeds, took place before it had been discovered that it was their nature to vegetate and produce according to their kinds, requires us to believe that men were possessed of some instinctive capacity. Again, if we admit that there was this faculty, we must likewise admit that it must have some excitement to act.—But had there been in our own species such an instinctive impulse to cultivate the soil, it might be expected to remain as a common capacity to the present time. We however perceive no such instinct in ourselves, nor have we any proof that it exists in others. It is our happy lot to be instructed by experience, and from this quarter we learn the consequences of ploughing the earth, sowing seeds, &c. This could not have been the case with man in the beginning; he had no experience to guide him, nor do we suppose that he was stored as we are with his wheat, his corn, and all other kinds of grain. His seeds were to collect from spontaneous productions, and the value of them as nourishment, he had to learn by experience. The probability is, that the first cultivator must have taken his lessons from observing the laws of nature. He must have noticed that on the spot where particular plants had grown, the seeds of those plants had fallen, and that the subsequent growth was more abundant there than in other situations. He must have tasted them and judged of their fitness for food; nor are those conjectures without an implied support from history. Through that medium we learn that our first parents were placed in a fertile part of the world; they lived where vegetable productions were no doubt abundant, upon these they had the opportunity to support themselves, but as the number of inhabitants were increased, it required that their supplies should correspond with the wants of nature, to obtain which, cultivation of the earth was necessary. How soon this cultivation began, we are not able to say. The Scriptures inform us, that "in process of time it came to pass, that Cain brought of the fruit of the ground an offering," and that he was a tiller of the ground.

We cannot gather from this circumstance that he was a cultivator, it is quite as probable that his offering was of spontaneous growth. We may from this passage conclude that Cain had in some way come to know that these fruits were valuable, but how he acquired this knowledge, we are left to conjecture. Among the numerous productions of the soil, a part only are fit for food; many others are known to be poisons; the distinction was necessary to be made, and we cannot conceive this distinction possible but by experience, unless we admit that different capacities were enjoyed at that early period from those which we possess, or that the Deity condescended to furnish the first of the human family with an immediate knowledge, and the history of this circumstance has not been handed down to us. The proofs which we have that cultivation was practised among the antediluvians, is to be gathered from Cain having been a tiller of the ground, and the case of Noah. This venerable father of a new world, stands at the head of Agriculture; he was the first that began planting after the Deluge. From these circumstances we may infer, that some attention was paid to it by the old world. But whatever might have grown out of their practice, or been known among them of agriculture, has been lost to a subsequent race. From the earliest accounts of eastern nations, we have reason to think that agriculture has long been understood by them in considerable perfection, as they were always supplied, not only with the necessaries, but even with the luxuries of life. As soon as the descendants of Abraham were settled in Palestine, they generally became husbandmen. High birth or rank at that time made no distinction; for agriculture was considered amongst the most honorable employments. Witness the examples of Gideon, of Saul, and of David.

The Chaldeans, who inhabited the country, where it is presumable agriculture had its birth, carried the art to a degree of perfection unknown to former ages.

The Egyptians, from the advantages of the overflowing of the Nile, raised vast quantities of corn, and were so sensible of the blessings arising from agriculture, that they ascribed the invention of that art to Osiris. Their superstitious gratitude was carried so far as to worship the animals employed in agriculture.

The divine honors paid to Bacchus in India, were derived from the same source; he being considered in that country, as the inventor of planting vineyards, and the other arts attendant on agriculture.

It is also related of the ancient Persians, that their kings laid aside their grandeur once a month, o eat with husbandmen. The precepts of their Religion taught by their ancient Magii or Priests, included the practice of agriculture.

The Phœnecians, so well known in Scripture by the name of Philistines, were remarkable for their attention to, and skill in agriculture.

Mago, a famous general among the Carthaginians, is said to have written no less than 28 books on the subject; which Columella tells us, were translated into Latin by order of the Roman Senate.

The Athenians appear to be the first among the Greeks, who acquired the arts of cultivation. This, we are informed, was taught them by Triptolemus; as the arts of agriculture increased, and the blessings they afforded became generally known, the people soon preferred them to the ravages of conquest, and the cruel depredations of savage life. Accordingly, we find the Athenian kings thinking t more glorious to govern a small state wisely, han to aggrandize themselves by foreign conquests, vithdraw their subjects from war, and employed nany of them in agriculture. Hesiod, was the irst we know among the Greeks, who wrote on this nteresting subject. According to the custom of riental writers, he wrote in poetry. He has called his poems weeks and days, because agriculture equires exact observations of times and seasons. Xenophon, has also in his œconomies, remarked hat agriculture is the nursing mother of the arts; or, says he, where agriculture proceeds prosperusly, there the arts thrive, but where the earth ecessarily lies uncultivated, there the other arts re destroyed.

The ancient Romans esteemed agriculture so onorable, that the most illustrious Senators of the empire, in the interval of public concerns, applied themselves to this profession.

Regulus, when in Africa, requested of the senate to be recalled, lest his farm might suffer. Cato, the censor, wrote a treatise on agriculture, which he dedicated to his son. Varro composed a treatise on the same subject. Columella, who flourished in the reign of Cladius, wrote 12 books on agriculture. From this period to that of the reign of Constantine Pogonatus, husbandry continued in a declining state, but that wise emperor caused a large collection of the most useful precepts relating to agriculture to be extracted from the best writers, and published them under the name of GEOPONICS.

After the death of Constantine, agriculture became a neglected science, and we find no vestige upon the subject until the year 1478, when Crescenzio published an excellent performance upon the subject, at Florence. This roused the slumbering attention of his countrymen, several of whom soon followed his example, among these Tatte, Steffano, Gallo, Sansovino, Lauro, and Tarillo, are said to deserve particular attention. At what time agriculture was introduced into Britain is uncertain. When Julius Cæsar first invaded that Island, it was not wholly unknown; he was of opinion that it was first introducèd by some of the Gauls, which had settled the southern parts of Britain, about one hundred years before the Roman invasion. It is not to be expected that we can now be acquainted with many of the practices of those ancient husbandmen. It appears, however, that they were acquainted with the use of manures, particularly Marle. This we have on the authority of Pliny, who tells us that it was peculiar to the people of Gaul and of Britain; that its effects continued 80 years, and that no man was ever known to marle his fields twice. It is probable that lime was at this time used as a manure, in Britain, as it was certainly used in Gaul at the time of Julius Cæsar's invasion.

The establishments of the Romans in Britain produced great improvements in agriculture, insomuch that prodigious quantities of corn were annually exported from the Island. But when the Roman power began to decline, this, like all other arts, declined also, and was almost totally destroyed by the departure of that people. Agriculture in England, continued to be interrupted in its progress by the various confusions and difficulties of warfare, until the time of the Norman invasion, 1066, when improvements again commenced, for by that event many thousands of husbandmen from Flanders, France and Normandy, settled in Britain, obtained estates or farms, and cultivated them after the manner of their country.—But we are left very much in the dark, as to the produce of the soil, or the system of agriculture, in England, until the latter end of the fifteenth century, about which time it seemed to have been cultivated as a science, and received very great improvements. From this time agriculture appears to have made a regular progress, to have been patronized among the leading characters of different countries, and many who were first in latent and literary acquirements published essays on the subject. Societies have been formed, with a design to render the cultivation of the earth an honorable calling.

We shall pass by the names of modern writers, as the introduction of them seems unnecessary in this short historical sketch. But it may be useful to give some further account of the measures resorted to for promoting agriculture. Among the Chinese it is distinguished and encouraged by the court, beyond all other sciences. The emperor of China, yearly, at the beginning of spring, goes to plough in person, attended by all the princes and grandees of the empire.—The ceremony is performed with great solemnity, and is accompanied with a sacrifice, which the emperor as high priest offers to Chang Ti, to secure a plentiful crop in favor of his people. At present it is given as an opinion, that Britain alone exceeds all modern nations in husbandry. For the last twenty years a liberal spirit of improvement has animated many of her nobility and gentry, and they have patronized agriculture. Hence there is reason to believe, that this most useful of all arts, will, in a few years, be carried to a greater pitch of perfection, than it has ever yet attained in that, or perhaps any other country. We have before mentioned the agricultural society in Philadelphia. It appears that in different parts of Europe there are similar societies, and no doubt remains but that this branch of science is making rapid advances. In our own country, we are gratified to see, that on the same farm where a few years since all seemed like poverty and distress, vast improvements have been made.—The use of lime, the introduction of gypsum and clover, have largely contributed to this happy change.

LECTURE IV.

On the Nature of Soils.

In our lectures upon the history and properties of simple earths, we have treated of six: beside these there are other substances in the soil, all of which are the objects of our enquiry. If the farmer is able to prove, by chemical tests, what are he defects of his farm, he will know how they hould be remedied. Hence it is evident that the omponent parts of the soil should be ascertained. When we comprehend these, our knowledge of undamental principles in agriculture will be coniderable. Professor Davy, in his Agricultural hemistry, has thrown much light upon the subect: he has analysed different soils and stated the results. A good turnip soil from Holkham, Norlk, afforded eight parts out of nine of silecious nd, and the finely divided matter consisted of

Carbonate of lime,	63
Silica,	15
Alumina,	11
Oxide of Iron,	3
Vegetable and saline matter,	5
Moisture,	3
	100

He found the soil taken from a field at Shefd-place, in Sussex, remarkable for producing irishing oaks, to consist of six parts of sand and part of clay and finely divided matter: and one hundred parts of the entire soil, submitted to analysis, produced

Silica,	54 parts.
Alumina,	28
Carbonate of lime,	3
Oxide of iron,	5
Decomposing vegetable matter,	4
Moisture and loss,	3
	97

An excellent wheat soil, from the neighborhood of West-Drayton, Middlesex, gave three parts in five of siliceous sand, and the finely divided matter consisted of

Carbonate of lime,	28
Silica,	32
Alumina,	29
Animal or vegetable matter and moisture,	11
	100

Of these soils the last was by far the most, an
first the least, coherent in texture. In all case
the constituent parts of the soil, which give tena
city and coherence, are the finely divided matters
and they possess the power of giving those quali
ties in the highest degree, when they contain muc
alumina. Vegetable or animal matters, when fin
ly divided, not only give coherence but likewis
softness and penetrability, but neither they n
any other part of the soil must be in too great pr
portion, and a soil is unproductive if it consis
entirely of impalpable matters. Pure alumina
silica, pure carbonate of lime, or carbonate of ma
nesia, are incapable of supporting healthy vege
tion. No soil is fertile that contains as much
19 parts out of 20 of the constituents that ha
been mentioned.

It will be asked, are the pure earths in the soil merely active as mechanical or indirect chemical agents? or do they actually afford food to the plant? This is an important question, and not difficult of solution. The earths consists of metals united to oxygen, and these metals have not been decomposed; there is consequently no reason to suppose that the earths are convertable into the elements of organized compounds, into carbon, hydrogen and azote.

Plants have been made to grow in given quantities of earth. They consume very small portions only, and what is lost may be accounted for by the quantities found in their ashes; that is to say it has not been converted into any new products. The carbonic acid united to lime or magnesia, if any stronger acid happens to be formed in the soil during the fermentation of vegetable matter which will disengage it from the earths, may be decomposed: but the earths themselves, so far as we know, are not convertable into other substances by any process taking place in the soil. In all cases the ashes of plants contain some of the earths of the soil in which they grow, but these earths never equal more than one fiftieth part of the weight of the plant consumed. Many soils are popularly distinguished as cold, and the distinction, though at first view it may appear to be founded on prejudice, is really just. Some soils are much more heated by the rays of the sun, all other circumstances being equal, than others; and soils brought to the same degree of heat, cool in different times, that is, some cool much faster than others. This property has been very little attended to, in a philosophical point of view, yet it is of importance in agriculture. In general, soils that consist principally of a stiff white clay, are difficult to heat, and, being usually very moist, they retain their heat only for a short time. Chalks are similar in one respect, that they are difficult to heat; but, being drier, they retain their heat longer, less being consumed in causing the evaporation of their moisture. A black soil, containing much soft vegetable matter, is most heated by the sun and air; and the coloured soils, and the soils containing much carbonaceous or ferrujenous matter, exposed under equal circumstances to the sun, acquire a much higher temperature than pale coloured soils.

When soils are perfectly dry, those that most readily become heated by the solar rays likewise cool most rapidly; but it has been ascertained, by experiment, that the darkest coloured dry soil, (that which contains abundance of animal or vegetable matter, substances which must facilitate the diminution of temperature,) when heated to the same degree, provided it be within the common limits of the effect of solar heat, will cool more slowly than a wet pale soil entirely composed of earthy matter. A rich black mould, which contained nearly one quarter of vegetable matter, had its temperature increased in an hour from 65° to 88° by exposure to sunshine, while a chalk soil was heated only to 69° under the same circumstances; but the mould, removed into the shade, where the temperature was 62°, lost in half an hour 15°, whereas the chalk, under the same circumstances, had lost only 6°.

These facts are interesting to the farmer. A soil which consists of parts whose capacity, taken collectively, for caloric, is the greatest, must be the best. Hence the thermometer may be used with advantage in aiding our judgment of soils. We might employ this instrument to decide the state of different parts of the same farm. From the foregoing results, given by Professor Davy, we learn that, where the capacity for heat is wanting, there we shall discover that either the simple earths are not correctly proportioned, or that further supplies of vegetable matter are necessary.

LECTURE V.

On the Soil, and methods of testing its State.

Besides the difference of capacity in the soil for caloric, furnishing a test by which its fertility may be known—the absorbent power operating by capillery attraction, and which will be in proportion to the reduction of the attraction of cohesion, is another test of much certainty. Experiments which have been made, are satisfactory on this point. They inform us that those soils which are justly named cold, are composed of parts which are strongly held together by the attraction of cohesion, and therefore have less of the power of absorption. But if the proportions of finely divided matter are sufficient to equalize the attraction of cohesion, or cause it to give way to the capillery attraction; such soils are capable of caloric, as also of absorption, and therefore productive. It is probable, that in those soils, heat diminishes the cohesive attraction, and therefore our improvement of them must necessarily depend upon applying for manure, such substances as separate their parts most perfectly. There is, however, one case of exception to the doctrine of absorption increasing in the same ratio with the decrease of cohesion. A soil which consists principally of alumina, will have the cohesive attraction reduced by mixing with it silica or sand; but the absorbing power will not be in the same proportion, as it is not in the nature of sand to be absorbent; in fact every particle of it so firmly united by corpuscubon as to prevent the capillery attraction. But when the soil is principally composed of alumina, silica may be usefully added, because the particles of the latter, form a permanent and valuable change for the better. This fact is supported by the results of analysis on good soils; those always possess the simple earths in favorable proportions. A soil, therefore, which is too close and hard, is to be opened and its tenacity changed. This process will be more particularly attended to, when we come to treat of the proper methods for improving soils. We have seen already that those soils which have the greatest capacity for absorption, have also the greatest capacity for caloric: both these circumstances furnish the opportunity to the farmer, to judge of the fertility of his land, and likewise to decide how to improve that which is defective. He may know the state of his farm by taking a small part of the soil of each field, and heating the same sufficiently to evaporate all moisture; after which, weigh the several parcels, and place them in the open atmosphere. When they have been 40 to 50 minutes so exposed, weigh them again, and the moisture absorbed may be distinctly ascertained. In performing this experiment, care should be taken not to raise the heat in drying the soil to 300 degrees, the point at which combustion is produced, otherwise the vegetable matter will be decomposed. Various other plans may be embraced to prove the state of a farm, perhaps few more simple or certain, and few again more completely at the command of every farmer. It has been alleged by some who have cultivated timothy, that this plant has a greater tendency to reduce the fertility of a farm than clover. There is great reason to apprehend the opinion is correct, but by taking of the soil in the same field, and testing the opinion either with the thermometer, or as above, by the capacity for absorption, it may be fully ascertained whether the opinion be correct or not. Professor Davy, has observed, that the great use of the soil is to afford support to the plant, to enable it to fix its roots, and to derive nourishment by its tubes slowly and gradually, from the soluble and dissolved substances mixed with the earths.

That a particular mixture of the earths is connected with fertility cannot be doubted, and almost all sterile soils are capable of being improved by a modification of their earthly constituent parts.

The necessity of water to vegetation, and the luxuriancy of the growth of plants connected with the presence of moisture in the southern countries of the old continent, led to the opinion so prevalent in the early schools of philosophy, that water was the great productive element, the substance from which all things were capable of being composed, and into which they were finally resolved. Van Helmont, in 1610, conceived that he had proved, by a decisive experiment, that all the products of vegetables were capable of being generated from water. His results were shown to be fallacious, by Woodward, in 1691; but the true use of water in vegetation was unknown till 1785, when Cavendish made the grand discovery, that it was composed of two elastic fluids or gasses, inflammable gas or hydrogen, and vital gas or oxygen. Jethro Tull, in his treatise on horse hoeing, published in 1783, advanced the opinion, that minute earthly particles supplied the whole nourishment of the vegetable world, that air and water were chiefly useful in producing these particles from the land, and that manures acted in no other way, than by ameliorating the texture of the soil; in short, that their agency was mechanical. This ingenious author of the new system of agriculture, having observed the excellent effects produced in farming, by a minute division of the soil, and the pulverisation of it by exposure to dew and air, was misled by carrying his principles too far. Duhamel, in a work printed in 1754, adopted the opinion of Tull, and stated, that by finely dividing the soil, any number of crops might be raised in succession, from the same land. He attempted also to prove by direct experiments, that vegetables of every kind were capable of being raised without manure. This celebrated horticulturist lived, however, sufficiently long to alter his opinion. The results of his later and most refined observations, led him to the conclusion that no simple material afforded the food of plants.

There is no idea more unfounded, than that a great devotion of time, and minute knowledge of general chemistry, is necessary for pursuing experiments on the nature of soils or the properties of manures. Nothing can be more easy than to discover whether a soil effervesces or changes color by the action of an acid, or whether it burns when heated, or what weight it loses by heat, and yet these simple indications may be of great importance in a system of cultivation. The expense connected with chemical enquiries, is extremely trifling; a small closet is sufficient for containing all the materials required. The most important experiments may be made by means of a small portable apparatus—a few phials, a few acids, and a crucible, are all that are necessary.

LECTURE VI.

On Vegetables.

Subsequently to our introductory, we have had lectures on the simple Earths, their properties, the history of Agriculture, and various tests by which the soil may be understood, and its component parts explained. It had been contemplated next to introduce lectures upon manures--but, upon reflection, a different course is chosen, and we shall now examine vegetables. We shall endeavor to comprehend and explain their nature, organization, and requisite supplies. You will readily perceive that this investigation is important in agriculture. In the first place, it is so, because it is only in proportion to our knowledge of the constitution of Vegetables that we are able to fix upon the manures which the soil, under different circumstances, may require. Secondly, it must be advantageous to know the substances of which vegetables are composed, because this knowledge will prepare us to decide whether the farm we cultivate demands additional aids, or is amply supplied for the contemplated crop. Is it possessed of the absorbent powers which indicate a good soil ? it may, notwithstanding, require some peculiar capacity, perhaps easily obtained, before it will furnish the growth of vegetables which should reward the labor of the husbandman. And lastly, it is important to understand the component parts of vegetables, because we can in no other way be so fully competent to judge of the necessary food of plants.

It was from these considerations that we have been induced to pursue our enquiries into the organization and constitution of vegetables, prior to to any thing being presented on the subject of manures.

All the different parts of plants are capable of being decomposed into a few elements. Their uses as food, or for the different purposes of art, depend upon compound arrangements of those elements, which are capable of being produced either from their organized parts, or from the juices they contain; and the examination of the nature of these substances is an essential part of Agricultural Chemistry.

Oils are expressed from the fruits of many plants; resinous fluids exude from the wood; saccharine matters are afforded by the sap, and dyeing materials are furnished by leaves or the petals of flowers.

The compound substances found in vegetables are, 1st. Gum or mucilage, and its different modifications. 2d, Starch. 3d, Sugar. 4th, Albumen. 5th, Gluten. 6th, Gum elastic. 7th, Extract. 8th, Tannin. 9th, Indigo. 10th, Narcotic principle. 11th, Bitter principle. 12th, Wax. 13th, Rosin. 14th, Camphor. 15th, Fixed oils. 16th, Volatile oil. 17th, Woody fibre. 18th, Acids. 19th, Alkalies, earths, metallic oxydes, and saline compounds. The properties and compositions of these bodies are, 1st. Gum is a substance which exudes from certain trees; it appears in the form of a thick fluid, but soon hardens in the air, and becomes solid; when it is white or yellowish white, more or less transparent, and somewhat brittle. Its specific gravity varies from 1300 to 1490.

There is a great variety of gums, but the best known are, gum Arabic, gum Senegal, gum Tragacanth, and the gum of the plum or cherry tree. Gum is soluble in water, but not soluble in spirits of wine. If a solution of gum be made in water, and spirits of wine or alcohol be added to it, the gum separates in the form of white flakes. Gum can be made to inflame only with difficulty; much moisture is given off in the process, which takes place with a dark smoke and feeble blue flame, and a coal remains.

The characteristic properties of gum, are its easy solubility in water, and its insolubility in alcohol. Different chemical substances have been proposed, for ascertaining the presence of gum, but there is reason to believe that few of them afford accurate results, and most of them (particularly the metallic salts) which produce changes in solutions of gum, may be conceived to act, rather upon some saline compounds existing in the gum, than upon the pure vegetable principle.

Mucilage must be considered as a variety of gum. It agrees with it in its most important properties, but seems to have less attraction for water. According to Hermbstads, when gum and mucilage are dissolved together in water, the mucilage may be separated by means of sulphuric acid. Mucilage may be procured from linseed, from the bulbs of the Hyacinth, from the leaves of the marsh mallows, from several of the lechens, and from many other vegetable substances. From analysis, it appears that Gum Arabic contains in 100 parts:

of Carbon, - - - - - - - - - - - -	42.23
Oxygen, - - - - - - - - - - - -	50.84
Hydrogen, - - - - - - - - - -	6.93

system of tubes or vessels, which, in one extremity, terminate in the roots, and, at the other, in leaves. It is by the capillary attraction of the roots that fluid matter is taken up from the soil. The sap, in passing upwards, becomes denser and more fitted to deposite solid matter. It is modified by exposure to heat, light, and air, in the leaves—descends through the bark in its progress—produces new organized matter, and is thus, in its vernal and autumnal flow, the cause of the formation of new parts, and of the more perfect evolution of parts already formed.

The chemical composition of plants has, within the last ten years, been elucidated by the experiments of a number of chemical philosophers, both in this and in other countries, and it forms a beautiful part of general chemistry. It is too extensive to be treated of minutely; but it will be necessary to dwell upon such parts of it as afford practical inferences.

If the organs of plants be submitted to chemical analysis, it is found that their almost infinite diversity of form depends upon different arrangements and combinations of a very few of the elements—seldom more than seven or eight belong to them, and three constitute the greatest part of their organized matter—and, according to the manner in which these elements are disposed, arise the different properties of the products of vegetation, whether employed as food or for other purposes and wants of life. The value and uses of every species of agricultural produce are most correctly estimated and applied when practical knowledge is assisted by principles derived from chemistry. The compounds in vegetables really nutritive as the food of animals, are very few—farina or the pure matter of starch, gluten, vegetable jelly, and extract. Of these the most nutritive is gluten, which approaches nearest in its nature to animal matter, and which is the substance that gives to wheat its superiority over other grain.—The next in order, as to nourishing power, is sugar; then farina, and, last of all, gelatinous and extractive matters. Simple tests of the relative nourishing powers of the different species of food are the relative quantities of these substances that they afford by analysis, and though taste and experience must influence the consumption of all articles, in years of plenty, yet they are less attended to in times of scarcity, and on such occasions this kind of knowledge may be of the greatest importance. Sugar and farina or starch are very similar in composition, and are capable of being converted into each other by simple chemical process.

All the varieties of substances found in plants are produced from the sap, and the sap of plants is derived from water, or from the fluids in the soil, and it is altered by, or combined with, principles derived from the atmosphere. The influence of the soil, of water, and of air, will, therefore, be the next subject of consideration. Soils, in all cases, consist of a mixture of different finely divided earthy matters, with animal or vevetable substances, in a state of decomposition, and certain saline ingredients. The earthy matters are the true basis of the soil—the other parts, whether natural or artificially introduced, operate in the same manner as manures. Four earths generally abound in soils—the aluminous, the siliceous, the calcareous, and the magnesian. These earths consist of highly inflamable metals united to pure air or oxygen, and they are not, as far as we know, decomposed or altered by vegetation.—

The great use of the soil is to afford support to the plant, to enable it to fix its roots, and to derive nourishment by its tubes slowly and gradually from the soluble and dissolved substances mixed with the earths. That a particular mixture of the earths is connected with fertility, cannot be doubted, and almost all sterile soils are capable of being improved by a modification of their earthy constituent parts.

The necessity of water to vegetation, and the luxuriancy of the growth of plants, connected with the presence of moisture, in the southern countries of the old continent, led to the opinion so prevalent in the early schools of philosophy, that water was the great productive element, the substance from which all things were capable of being composed, and into which they were finally resolved. Air, like water, was regarded as a pure element by most of the ancient philosophers. A few of the chemical enquirers, in the sixteenth and seventeenth centuries, formed some happy conjectures respecting its real nature. But the true statistical analysis of the atmosphere is comparatively a recent labor, achieved towards the end of the last century by Scheele, Priestly and Lavoisier. These celebrated men shewed that its principal elements are two gases, oxygen and azote, of which the first is essential to flame and to the life of animals, and that it likewise contains small quantities of aqueous vapor, and of carbonic acid gas, and Lavoisier proved that this last body s itself a compound elastic fluid, consisting of charcoal dissolved in oxygen. But though neither water, nor air, nor earth, supplies the whole of he food of plants, yet they all operate in the great process of vegetation. The soil is the laboratory in which the food is prepared. No manure can be taken up by the roots of plants unless water is present, and water or its elements exists in all the products of vegetation. The germination of seeds does not take place without the presence of air or oxygen gas, and in the sun-shine vegetables decompose the carbonic acid gas of the atmosphere, the carbon of which is absorbed and becomes a part of their organized matter, and the oxygen gas, the other constituent, is given off, and in consequence of a variety of agencies, the economy of vegetation is made subservient to the general order of the system of nature.

LECTURE XIII.

The Phenomena of Fluidity.

Fluidity is that state or affection of bodies which exhibits them in a liquid form.

All substances in nature, as far as we are acquainted with them, occur in one or the other of the three following states. The solids, the liquids, or the elastic fluids or vapours. It has been ascertained that, in a vast number of cases, the same substance is capable of existing successively in each of these states. Thus sulphur is usually a solid body, but when heated to 212°, it is converted into a liquid; and at a still higher temperature, (about 570°,) it assumes the form of an elastic vapour of a deep brown color. Water, also, in our climate, is, for the greater part of the year, a liquid, but when cooled down to thirty-two degrees, it is converted into a solid body, and at 212° it assumes the form of an elastic fluid.—All solid bodies, a very small number excepted, may be converted into liquids by heating them sufficiently; and on the other hand, every liquid, except spirit of wine, is convertable into a solid body, by exposing it to a sufficient degree of cold. All liquid bodies may, by heating them, be converted into elastic fluids, and a great many solids are capable of undergoing the same change; and lastly, the number of elastic fluids which, by cold, are condensible into liquids or solids, is by no means inconsiderable. These facts have led philosophers to this general conclusion, that all bodies, if placed in a temperature sufficiently low, would assume a solid form; that all solids become liquids when sufficiently heated, and that all liquids, when exposed to a certain temperature, assume the form of elastic fluids. The state of bodies then depends upon the temperature in which they are placed in the lowest temperatures; they are all solid. In the higher temperatures, they are converted into liquids, and in the highest of all, they become elastic fluids. The particular temperatures at which bodies undergo those changes are exceeding various, but they are always constant for the same bodies. Thus, we see that heat produces changes in the state of bodies, converting them first into liquids, and then elastic fluids.

When solid bodies are converted by heat into liquids, the change, in some cases, takes place at once. There is no interval between solidity and liquidity; but in other cases a gradual change may be perceived, the solid becomes first soft, and it passes slowly through all the degrees of softness, till at last it becomes perfectly fluid. The conversion of ice into water, is an instance of the first change, for in that substance there is no intervening state between solidity and fluidity. The melting of glass, of wax, and of tallow, exhibits instances of the second kind of change, for these bodies pass through every possible degree of softness before they terminate in perfect fluidity. In general, those solid bodies which chrystalize, or assume regular prismatic figures, have no interval between solidity and fluidity, while those that do not usually assume such shapes, have the property of appearing successively in all the intermediate states.

Solid bodies never begin to assume a liquid form till they are heated to a certain temperature;

this temperature is constant in all. In the first class of bodies, it is very well defined; but in the second, though it is equally constant, the exact temperature of fluidity cannot be pointed out with such precision, on account of the infinite number of shades of softness through which the bodies pass before they acquire their greatest possible fluidity. But even in these bodies we can easily ascertain that the same temperature always produces the same degree of fluidity.

The temperature at which this change from so-idity to liquidity takes place, receive different ıames, according to the usual state of the body hus changed. When the body is usually observ-d in a liquid state, we call the temperature t which it assumes the form of a solid, its freez-ng or congealing point. Thus, the temperature ı which water becomes ice, is called the freezing oint of water; on the other hand, when the body usually in the state of a solid, we call the tem-erature at which it liquifies, its melting point: us, 212° is the melting point of sulphur, 442° e melting point of tin. The following table ntains a list of the melting points of a consider-le number of solid bodies.

stances.	Melting point.	Substances.	Melting point.
Lead,	594°	Milk,	30°
Bismuth,	576	Vinegar,	28
Tin,	442	Blood,	25
Sulphur,	212	Oil of Bergamot,	23
Wax,	142	Wines,	20
Spermaceti,	133	Oil of Turpentine,	14
Phosphorus,	100	Sulphuric acid,	36
Tallow,	92	Mercury,	39
Oil of anise,	50	Liquid Ammonia,	46
Olive oil,	36	Æther,	46
ce,	32	Nitric acid,	66

Before Dr. Black began his chemical lectures in Glasgow, in 1757, it was universally supposed that solids were converted into liquids, by a small addition of heat, after they had been once raised to the melting point, and that they returned again to the solid state, on every small diminution of the quantity of heat necessary to keep them at that temperature. An attentive view of the phenomena of liquefaction and solidification, gradually led this sagacious philosopher to observe their inconsistence with the then received opinions, and to form another which he verified by direct experiments, and drew up an account of his theory and the proofs of it, which was read to a literary society in Glasgow, April 23, 1762, and every year after, gave a detailed account of the whole doctrine, in his lectures. The opinion which he formed was, that when a solid body is converted into a liquid, a much greater quantity of heat enters into it than is perceptible immediately after, by the thermometer. This great quantity of heat does not make the body apparently warmer, but it must be thrown into it, in order to convert it into a liquid, and this great addition of heat is the principal and most immediate cause of the fluidity induced. On the other hand, when a liquid assumes the form of a solid, a very great quantity of heat leaves it without sensibly diminishing its temperature, and the state of solidity cannot be induced without the abstraction of this great quantity of heat; or in other words, whenever a solid is converted into a fluid, it combines with a certain dose of caloric, without any augmentation of its temperature, and it is this dose of caloric which occasions the change of the solid into a fluid. Such are the opinions concerning the cause of fluidity, taught by Dr. Black, as early as 1762.